INSTRUCTION BOOK

for

# MODEL 305A PEAK RESPONDING ELECTRONIC VOLTMETER

BALLANTINE LABORATORIES, INC.
BOONTON, NEW JERSEY

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## WARRANTY

Each Ballantine Laboratories, Inc. instrument, or part thereof, is warranted to be free from defects in material and workmanship. Ballantine Laboratories, Inc. obligation under this warranty is limited to repairing or replacing any instrument or part thereof, except vacuum tubes and batteries, which shall within one year after shipment to the original purchaser prove upon Ballantine Laboratories, Inc. examination to have become defective.

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# FOR

# MODEL 305A PEAK RESPONDING ELECTRONIC VOLTMETER


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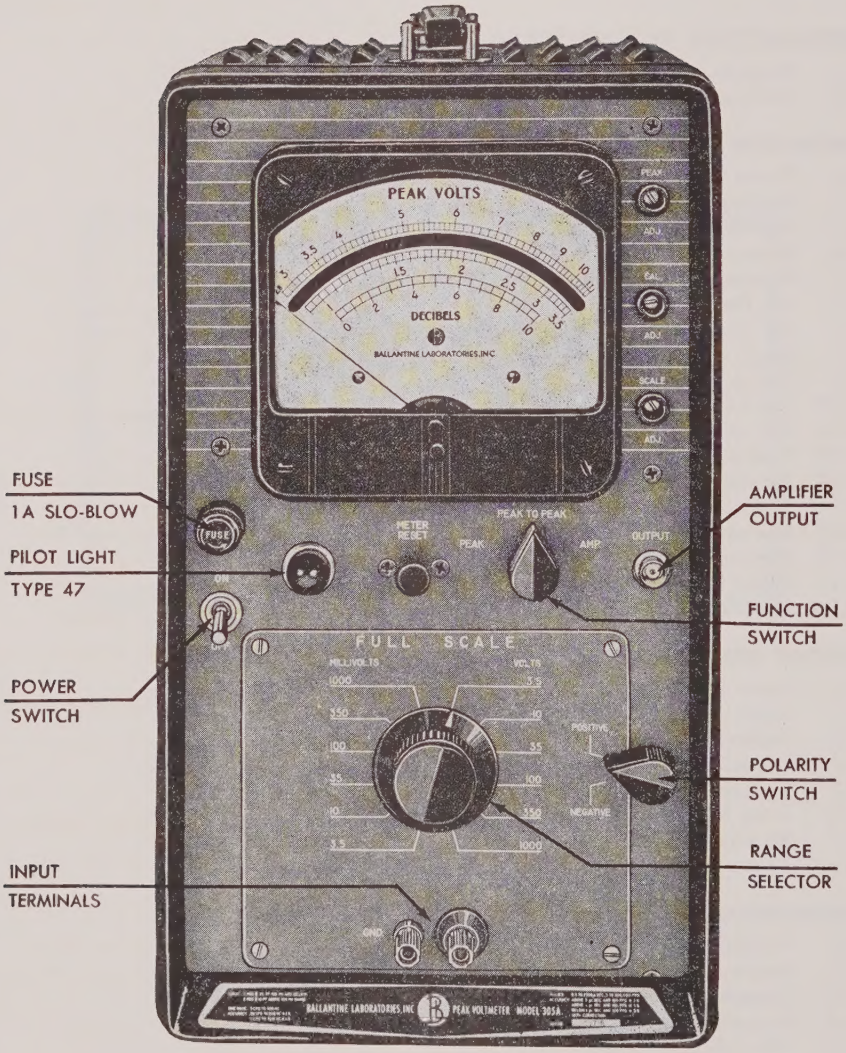



**Ballantine Model 305A**
**Peak Responding Electronic Voltmeter**

# 1. INTRODUCTION AND DESCRIPTION

## 1.1 Purpose and Use

The Ballantine Model 305A Peak Responding Electronic Voltmeter is an amplifier-detector type instrument provided with a peak detector circuit for peak-to-peak or peak value measurements. The instrument indicates peak-to-peak or negative peak amplitudes of repetitive waveforms including sine, square, triangular and complex waves, and pulse trains.

The measurement is indicated on either of two logarithmic voltage scales which allow the same high accuracy at all points. A third linear decibel scale with a range of 10 decibels is also provided.

The sensitive and stable wide-band amplifiers associated with a special peak detector circuit extend the sensitivity of the instrument into the microvolt region. This allows the measurement of low energy pulse trains with pulse widths down to 0.5 microsecond and repetition rates as low as 5 pps.

In addition to its function as a voltmeter, the 305A may be used as a wide-band, fast rise-time amplifier.

The instrument design provides all controls and adjustments on the front panel. The Model 305A may be obtained in portable and rack-mounted versions.

## 1.2 Technical Characteristics

### Voltage Range

1 millivolt to 1000 volts peak-to-peak or peak in 12 ranges.

### Frequency Range

5 to 500,000 cps. sine wave — 200 to 300,000 cps. square wave.

### Pulse Range

Duration — 0.5 to 2,500 microseconds. Repetition rate — minimum 5 pps.

### Accuracy

Sine Wave — ±2% 20 cps. to 200 kc.
±4% 5 cps. to 500 kc.

Square Wave — ±3% 200 cps. to 300 kc.

Pulses — ±3% above 3 microseconds and 100 pps.
±5% above 1 microsecond and 100 pps.
±5% below 1 microsecond and 100 pps. when correction is used.
±5% below 3 millivolts for all waveforms.

### Input Impedance

2 megohms shunted by 10 pF on 350 millivolt range and above. 2 megohms and 25 pF below 350 millivolt range.

### Meter Scales

Logarithmic voltage scales from 0.9 to 3.5 and 2.8 to 11. Linear decibel scale from 0 to 10.

### Amplifier Characteristics

Output — Amplifier output available at BNC connector marked OUTPUT.

Gain — Maximum of 86 DB ±1 DB adjusted in 10 DB steps with range selector.

Frequency Response — 5 to 500,000 cps. ±3% if loading above 1 megohm with parallel capacity below 10 pF.

Source Impedance — At 1 kc approximately 3 ohms in series with 0.22 $\mu$F.

Maximum Output Voltage — 70 volts positive, 40 volts negative.

Maximum Loading — 30,000 ohms and 10 pF.

### Warmup Drift

Less than 0.3% after 15 minute warmup.

### Noise

10 to 14 microvolts RMS referred to first grid.

### Line Voltage Effects

Specified accuracy over 100 volts to 130 volts or 200 volts to 260 volts line voltage.

### Power Supply

100 to 130 volts or 200 to 260 volts 60 cycles 82 watts. The voltmeter is intended for 60 cycles 115 volts or 230 volts line use.

### Dimensions

8 inches wide, 15 inches high, 10 inches deep.

### Weight

Instrument alone, 21 pounds — shipping weight 40 pounds.

# 2. OPERATION

## 2.1 Power Connection

The voltmeter is supplied ready to operate on 100 to 130 volts 60 cycles power. A decal mounted adjacent to the power cord indicates this voltage and frequency. For highest stability a magnetically regulated power transformer is used in the instrument. To realize the full advantage of the transformer the instrument must be operated from a 60 cycle, frequency stable line.

**2.1.1 — Line Voltage Conversion** — The 305A may be converted for 200 volts to 230 volts 60 cycles line operation with instructions given on the schematic diagram at the end of this book.

## 2.2 Starting Procedure

Insert the three prong power plug into the AC outlet or use the conversion unit. Move the power switch to ON position. Red pilot light should glow.

For initial turn-on, or if instrument has been out of use for many months, permit a warmup period of at least 30 minutes. In other cases 10 minutes will suffice.

**PERMIT AIR TO CIRCULATE FREELY AROUND THE INSTRUMENT.** The voltmeter is calibrated in the vertical position and is intended for use in this manner. For convenient reading a tilting device is provided beneath the case.

### 2.3 Function of Switches

| TITLE | POSITION | FUNCTION |
|---|---|---|
| Power | ON | Applies AC Power to Instrument |
| | OFF | Removes Power |
| METER RESET | Depressed | Decreases discharging time constant of detector from 3.3 to 0.7 seconds for fast decay of pointer. When depressed, the reading is highly in error and no measurement should be taken in this position |
| Function Switch | PEAK | Disables Negative Peak Detector Instrument indicates Peak Amplitude |
| | PEAK-TO-PEAK | Instrument measures Peak-to-Peak Amplitude of Input Waveform |
| | AMP | Connects Output Amplifier to Output Jack<br>Detector Circuit is disconnected |
| Polarity | POSITIVE | The output of the amplifier is in phase with the voltmeter input. With function switch in PEAK position, instrument indicates positive peak |
| | NEGATIVE | The output is out of phase with the voltmeter input. With function switch in PEAK position, instrument measures negative peak |
| Range Selector | MILLIVOLTS 3.5 to 1000<br>VOLTS 3.5 to 1000 | Attenuates input signal and indicates full scale voltage. |

### 2.4 Measurement of Peak-to-Peak Amplitudes

**2.4.1 — Measurement of Peak-to-Peak Value of Symmetrical Waveforms (AC)** — Measurement of nearly symmetrical waveforms whose positive and negative amplitudes differ by less than a 1 to 2 ratio is accomplished by the following procedure:

| SET | TO |
|---|---|
| Function Switch | PEAK-TO-PEAK |
| Polarity Switch | POSITIVE |
| Range Selector | 1000 volts and turn counter-clockwise until the meter gives a steady deflection |
| METER RESET | Depress to speed decay of pointer. Release and take reading or wait for indicator decay |

**2.4.2 — Measurement of Peak-to-Peak Value of Unsymmetrical Waveforms and Pulse Trains** — Use the following procedure:

| SET | TO |
|---|---|
| Function Switch | PEAK-TO-PEAK |
| Polarity Switch | POSITIVE, if Positive Peak is Higher in Amplitude, or NEGATIVE, if Negative Peak is Higher. If waveform is not exactly known, use peak measurement to determine higher peak. If polarity switch is not in agreement with higher peak, the accuracy of measurement may be affected. |
| Other Controls | As in 2.4.1 |

### 2.5 Measurement of Peak Amplitudes

Before making a peak value measurement the PEAK ADJ control should be checked for calibration. The checking and readjustment procedures are outlined under 2.11.3.

Changing the position of the polarity switch may cause a switching transient when making a peak measurement. This effect may be eliminated by switching the polarity switch to positive and then negative shortly before measuring.

The procedure for measuring the peak value of a waveform depends on its degree of symmetry.

**2.5.1 — Nearly Symmetrical Waveforms with Positive and Negative Amplitudes in Less than a 1 to 2 Ratio** — Proceed as follows:

| SET | TO |
|---|---|
| Function Switch | PEAK |
| Polarity Switch | POSITIVE to measure Negative Peak, NEGATIVE to measure Negative Peak |
| Other Controls | As in 2.4.1 |

**2.5.2 — Unsymmetrical Waveforms with Peak Amplitudes in More than 1 to 2 Ratio.** Only the higher peak amplitude can be measured accurately. The lower peak may be calculated by subtracting the higher peak amplitude from the peak-to-peak value as measured in 2.5.

| SET | TO |
|---|---|
| Function Switch | PEAK |
| Polarity Switch | Position giving Higher Indication |
| Other Controls | As in 2.4.1 |

### 2.6 AC Overload Considerations

The instrument is designed to withstand severe overloads without damage to components.

The maximum AC voltage which may be applied to the instrument on the four lowest ranges is limited by the maximum allowed voltage to the grid of the first tube. For an

extended time this should not exceed 100 volts peak-to-peak. The input tube may not necessarily be damaged by higher voltages applied for a short time.

| RANGE | MAXIMUM INPUT |
|---|---|
| 3.5 to 100 millivolts | 100 v peak-to-peak or 35 v RMS |
| 350 millivolts to 1000 v | 1000 v peak-to-peak or 350 v RMS |

### 2.7 DC Component of Input Signal

The voltage measurement by the instrument does not include the dc component of the signal. If the dc component is measured independently the complete peak values may be calculated by adding algebraically.

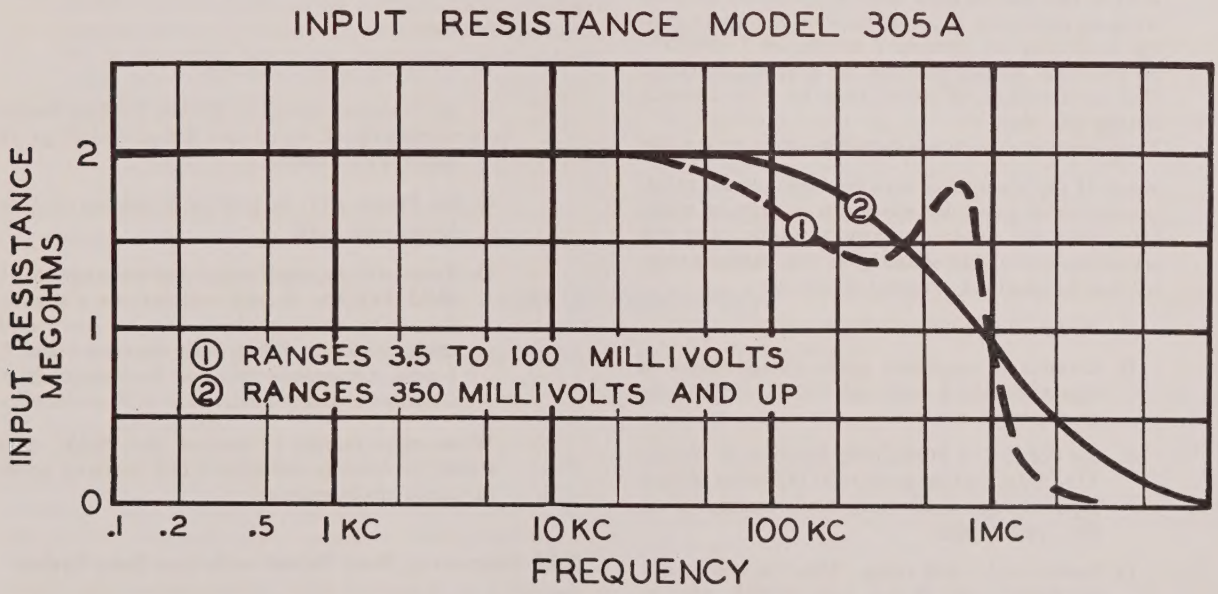
The maximum dc input to the instrument is 1000 volts. If the dc input is greater, an external capacitor must be connected in series with the insulated input terminal. For measurements down to 5 cycles this capacitor should be 0.22 $\mu$F or higher.

### 2.8 Input Impedance

The input impedance of the instrument depends on the setting of the range switch. For ranges of 350 millivolts and above, the input impedance is represented by 10 pF in parallel with 2 megohms. For ranges from 3.5 millivolts to 100 millivolts the input impedance is 25 pF in parallel with 2 megohms.

The capacitive component of input impedance is practically constant over the entire frequency range of the instrument. The resistive component changes with frequency as shown in the following graph.

In normal use with low impedance sources, the input impedance does not present any appreciable loading. However, when the source impedance approaches 10,000 ohms the effects of loading should be considered.




### 2.9 Use as an Amplifier

The instrument may be employed as a wide-band fast rise-time amplifier to deliver up to 70 volts into a low capacitance load. For use as an amplifier:

| SET | TO |
|---|---|
| Function Switch | AMPL |
| Polarity Switch | POSITIVE for In-Phase Output<br>NEGATIVE for Reversed Output |
| Range Switch | Range to give Scale Reading or to a Higher Range |

Connect input signal to input terminals and take output from BNC connector marked OUTPUT. Adjust range switch for desired amplification without distortion.

Amplifier characteristics are described in 1.2, 2.6, 2.7 and 2.8.

To utilize the full frequency range and shortest rise-time of the amplifier the capacitive loading at the output must not exceed 10 pF and the load resistance should not be below 30,000 ohms.

Capacitive loading of the output may be increased above 10 pF if fast rise-time and wide band-width are not required. The resistive loading may also be increased if maximum output voltage is not necessary.

### 2.10 Panel Controls with Screw Adjustment

Three adjustable controls are provided to the right of the indicating meter.

| CONTROL | FUNCTION |
|---|---|
| SCALE ADJ | Controls the Scale Linearity |
| CAL ADJ | Controls the Sensitivity and Calibration of the Instrument. *Adjustment of this* |

*control affects the instrument's accuracy and should only be undertaken after reading Section 4.6.3, and when required accurate calibration equipment is available.*

PEAK ADJ — Controls the Scale Linearity of Peak measurement and may be changed to allow Peak measurement below 1 millivolt.

The controls are set at Ballantine Laboratories for best overall accuracy on a wide variety of waveforms.

The SCALE ADJ and PEAK ADJ controls may be readjusted to compensate for tube aging or for special measurements as in 2.11.1 and 2.11.3. These adjustments should be checked every 200 hours of operation.

### 2.11 Use of Adjustable Controls

**2.11.1 The SCALE ADJ control** should be adjusted when an indication of precisely 10 on the upper voltage scale does not produce a reading of 1 ±0.25% on the lower voltage scale on the next higher range. The input voltage, of course, must be quite constant during this check.
For general use this check should be made with a sine wave. If the instrument is to be used only for measurement of a particular waveform or type of waveform, then the adjustment may be made using this waveform and higher accuracy on this particular signal will be obtained. Proceed as follows:

A. Allow 30 minutes or more warmup.

B. Connect an amplitude stable voltage source of approximately 1 volt and 100 to 2000 cycles to the input terminals.

C. Set polarity to POSITIVE, function to PEAK-TO-PEAK and range to 1000 millivolts. Adjust input voltage until meter reads exactly 10 on the upper scale.

D. Switch to 3.5 volt range. Meter should read 1 on lower scale. If not, turn SCALE ADJ to give exactly 1. Tap meter face lightly during measurement to reduce friction effects.

E. Repeat C and D until indicated range agrees with attenuator range to within ±0.1%.

**2.11.2 CAL ADJ — DO NOT READJUST** — See Note in 2.10.

**2.11.3 PEAK ADJ** — is to be adjusted if, when measuring perfectly symmetrical waveforms, the PEAK indication is not exactly 50% of the PEAK-TO-PEAK indication.

Procedure:

A. Allow at least 1 hour warmup. Set Function Switch to PEAK-TO-PEAK, Polarity Switch to POSITIVE and Range Switch to 1000 MILLIVOLTS.

B. Connect a stable distortionless (less than 0.5%) sine wave source of approximately 1 volt and 100 to 2000 cycles to the input terminals. Adjust the input voltage for an indication of 10 on the upper scale.

C. Set Function Switch to PEAK. The indication should be exactly 5. If not, adjust PEAK ADJ until an indication of 5 ±0.20% is obtained. Tap meter slightly as in 2.11.1.-D.

### 2.12 Peak Measurements Below 1 Millivolt

The PEAK ADJ control may be used to extend the voltmeter range for peak measurement down to 10 microvolts. This also allows use of the voltmeter as a sensitive peak responding null detector.

The frequency range for extended measurement is the same as for all PEAK indications. The specified accuracy applies, to which an additional error of ±10 microvolts is added.

Procedure:

A. Short the input terminals.

B. Set Function Switch to PEAK, Polarity Switch to polarity of signal and Range Switch to 10 millivolts or above.

C. Set PEAK ADJ to give an indication of 1 on lower volts scale.

D. Remove short, apply signal and set range to 3.5 MILLIVOLTS. Pointer will indicate a slightly fluctuating reading which may be interpreted using the lower voltage scale between 1 and 2. 1 now corresponds to 0 and 2 corresponds to 1 millivolt. Every subdivision is 50 microvolts.

When measurement is finished, the PEAK ADJ should be reset according to 2.11.3 to avoid errors in normal measurement.

### 2.13 Measuring Short Pulses with Low Duty Cycles

When pulses with duration less than 1 microsecond or repetition rates below 100 pps are measured, and when the duty cycle is below 0.002, a correction should be added to the readings if the readings fall between 0 and 4 db on the decibel scale.

The correction depends upon the duty cycle, thus:

| Duty Cycle ( Pulse Width In (Sec. X Rep. Rate in Sec.$^{-1}$) ) | Add To Reading | Multiply Reading By |
|---|---|---|
| 0.0002 to 0.002 | +2% | 1.02 |
| 0.00002 to 0.0002 | +4% | 1.04 |
| below 0.00002 | +6% | 1.06 |

The measuring error decreases with increasing indication so that the readings above 4 db on the decibel scale are within specified accuracy. When corrections are applied to readings below 4 db, the total error does not exceed ±5%.

### 2.14 Techniques for Higher Accuracy Measurements

The instrument accuracy is specified for the SCALE ADJ control set with a sine wave input. This provides the best compromise between accuracy and variety of measureable waveforms in normal use.

Generally, if accuracy is foremost, Peak-to-Peak measurement should be preferred to peak measurement, or if peak measurements are made the PEAK ADJ should be checked according to 2.11.3.

For some special waveforms higher accuracy measurements are possible when techniques described below are used.

**2.14.1** Measuring flat top waveforms, pulse trains and square waves may be made up to 1% more accurate by setting the SCALE ADJ with the particular waveform as described in 2.11.1.

**2.14.2** In measuring below 10 cycles set POLARITY Switch to NEGATIVE.

**2.14.3** When measuring below 3 millivolts, the noise of the input stage affects the accuracy. This noise is approximately 10 to 12 microvolts rms as referred to the first grid. The actual error depends upon the signal amplitude and waveform. For sine wave the corrections are thus:

| AT | CORRECTION |
|---|---|
| 1 Millivolt | —4% |
| 3 Millivolts | —1.5% |

Above 4 Millivolts the noise error is negligible.

### 2.15 Use as an Ammeter

When the Model 305A is coupled with the Ballantine Series 600 Shunt Resistors, peak currents from 1 microampere to 10 amperes may accurately be measured. These and other accessories may be found in the general catalog of Ballantine instruments.

### 2.16 Measuring Above 1000 Volts Peak

With the Ballantine Model 1305B Voltage Multiplier, the range of the 305A may be extended to 28 kilovolts Peak-to-Peak.

### 2.17 Power Line Effects

The instrument is operative from 80 volts to 140 volts and 58 cycles to 65 cycles.

Line variations from the specified operating voltage affects the accuracy of the instrument by approximately ±0.15% per 10% of line voltage change.

Line frequency variations change the accuracy by approximately 0.5% per cycle deviation from 60 cycles.

### 2.18 Effect of R. F. Line Transients

Line transients may enter the instrument through the input circuitry and affect the indication. Careful shielding of the input leads is a necessity when the power line contains large transients of this type and accurate measurements are desired. The voltmeter does not respond to these transients through its own power cord.

## 3. CIRCUIT DESCRIPTION

The block diagram, schematic and replacement parts list are included at the end of the instruction book.

### 3.1 Input Attenuator

The voltage to be measured is applied through the input sending parts and dc blocking capacitor C1 to the input attenuator. This attenuator is at lower frequencies a resistive divider and presents a 2 megohms load to the input signal. At higher frequencies above 25 kc the attenuator becomes a capacitive divider. The dividing ratio of latter is adjusted to the correct value by trimmers C2 and C3. The attenuation ratios are as follows:

| Range Switch Setting FULL SCALE | Input Att. | Attenuation Ratio Midsection Att. | Total |
|---|---|---|---|
| 3.5 MV | 1 | 1 | 1 |
| 10 MV | 1 | 3.162 | 3.162 |
| 35 MV | 1 | 10 | 10 |
| 100 MV | 1 | 31.62 | 31.62 |
| 350 MV | 31.62 | 3.162 | 100 |
| 1000 MV | 31.62 | 10 | 316.2 |
| 3.5 V | 31.62 | 31.62 | 1000 |
| 10 V | 1000 | 3.162 | 3162 |
| 35 V | 1000 | 10 | 10000 |
| 100 V | 1000 | 31.62 | 31620 |
| 350 V | 31620 | 3.162 | 100000 |
| 1000 V | 31620 | 10 | 316200 |

### 3.2 Input Amplifier

The input amplifier consists of two capacitively coupled penthode stages V1 and V2 followed by a direct coupled split-phase inverter stage V3. The amplifier has over 40 db negative feedback at midfrequencies with the roll-off rate of 6 db per octave at the high and low frequency ends. The response at the high frequency end is adjustable to a limited amount by variable capacitor C6

The first stage tube V1 is shock-mounted and shielded to reduce microphonics and hum pickup. First and second stage heaters are operated with dc. The plate voltage of direct coupled stage V2 can be adjusted with the screen series resistor R18. Neon bulb NE2 protects V3 in case of V2 failure or removal.

The Polarity switch S2 connects the following buffer stage to the plate or cathode of the phase inverter stage V3 which inverts the phase of the signal so that the output amplifier is always driven positively to assure fast rise-time and prevent cut-off of the output stage.

### 3.3 Buffer Stage and Midsection Attenuator

Buffer stage V4 is a cathode follower which couples the high source impedance of the plate of input amplifier to the relatively low resistance midsection attenuator. To equalize the high frequency response of the plate take-off (NEGATIVE) with the high frequency response to the cathode take-off (POSITIVE) a variable capacitor C15 is

connected to the cathode when signal is taken from the plate.

The midsection attenuator is a four-step string attenuator. Over most of the frequency range it acts as a resistive divider. Fixed capacitors C18 and C19 provide correction at the highest frequency range of the instrument.

### 3.4 Output Amplifier

The output amplifier consists of two capacitively coupled penthode stages V5 and V6 and a direct coupled cathode follower V7. The loop feedback is approximately 38 db at midfrequencies with a roll-off rate of 6 db per octave at both ends of the frequency response. The high frequency response is slightly adjustable by the variable capacitor C20. The heater of V5 is operated with dc. The plate voltage of V6 may be adjusted with screen resistor R41. Neon bulb V8 limits the cathode voltage of V7 during the warmup period and protects the tube.

### 3.5 Peak-to-Peak Detector

The output amplifier is connected over capacitor C26 and function switch S3 to the peak-to-peak detector which consists of two vacuum diodes, V12 for positive and negative detection and a charging capacitor C32. Divider R57, R58 provides a dc bias to the detector.

The diodes charge capacitor C32 with a short time constant of approximately 0.01 microseconds. C32 discharges over a 22 megohm resistor R59 with a time constant of 2.2 milliseconds. A high discharging-charging time constant ratio insures true peak detection of the input signal.

The detector stages are connected to the differential cathode follower V13. C33 between the grid and cathode of V13 increases the detector efficiency for low repetition rate pulses.

### 3.6 Pulse Stretcher

The differential cathode follower V13 which acts as an impedance transformer feeds the signal to another pair of peak rectifiers V14 which together with condensers C34 and C35 are charged to the peak value of signal. The discharge over resistors R63 and R64 has very long time constant of 3.3 seconds so that the peak charge on C34 and C35 stays almost constant, even between a pulse train for repetition rate of 5 pps.

For fast discharge R62 and R65 can be connected parallel to R63 and R64 by operating the METER RESET Switch S4.

For peak-to-peak measurement both capacitors C34 and C35 are connected to the second differential cathode follower V15. For peak measurement the negative channel of the pulse stretcher is disconnected by Function Switch S3 and an adjustable bias over the divider R66, R68 and PEAK ADJ R67 is fed to the cathode follower. With PEAK ADJ the scale linearity for peak measurement is controlled.

### 3.7 Measuring Stage

The cathode follower V15 feeds a shaped pole piece moving coil indicator. The current range of the indicator from 0 to 10 db is 190 to 600 microamperes.

The CAL ADJ control R76 in series with the indicator changes the voltage sensitivity of the indicator and is used to set the sensitivity of the instrument during calibration. The SCALE ADJ control R70 affects the balance of the differential cathode follower. It influences the on-scale indication more than the full scale indication, and so is used to control the scale linearity of indication.

The heaters of all tubes in the peak detector-pulse stretcher circuit are regulated to assure high stability of balance against line voltage variations.

### 3.8 Power Supply

A constant voltage transformer together with electronic regulation is used in power supply to stabilize the heater and +B voltages and achieve excellent stability against line voltage changes and transients. A silicon rectifier voltage doubler circuit is used in the +B rectifier circuit. Three separate filament circuits are used. One XX for tubes in power supply, one YY for amplifiers, and a rectified dc filament for tubes V1, V2 and V5.

## 4. MAINTENANCE

### 4.1 General

The instrument is designed for an extended period of trouble-free service. The loading of components and tubes is kept well below ratings, the tube heaters are regulated and the operating temperature of all components is low. It is expected that under normal laboratory use the tube life will extend to 4000 hours without need for recalibration of the instrument. When the tubes are replaced with tubes of normal characteristics the voltmeter performance will be restored without the need of extensive calibration.

A periodic maintenance as described below is recommended to guarantee the maximum accuracy of the instrument and help prevent possible breakdowns in service.

### 4.2 Recommended Maintenance Procedure

The following periodic checks are recommended.

**4.2.1 Every 200 hours** a scale and peak adjustment check.

**4.2.2 Every 1000 hours** a 1000 hour check.

**4.2.3 Every 2000 hours** a 2000 hour check.

### 4.3 Necessary Maintenance Equipment

To perform the tests listed under 4.2 the following equipment is needed:

**4.3.1** A variable output (approx. 1 volt) stable voltage source 400 cycles to 2 kc with below 0.5% waveform distortion. (For checks 4.2.1, 4.2.2 and 4.2.3.)

**4.3.2** A dc voltmeter 1 volt to 500 volts with 10 megohms input resistance ±3% accuracy. (For checks 4.2.2 and 4.2.3.)

**4.3.3** A voltage calibrated (± 0.5% or better) distortion-free source, 400 cycles to 2 kc (such as Ballantine Model 420 Precision Calibrator or an accurate ±0.5% or better) voltmeter with stable distortion-free voltage source. (For tests 4.2.2 and 4.2.3.)

**4.3.4** A tube checker which measures tube transconductance. (For test 4.2.3.)

### 4.4 Removal of the Case

The tests 4.2.2 and 4.2.3 require the removal of the case, which can be done as follows:

a. Place the instrument with the front panel down on a table.

b. Remove the power cord, unscrew the three #10 binder head screws from the back.

c. Lift up the case.

To put the case back proceed in reverse order.

**WARNING: WHEN INSTRUMENT IS OPERATED WITHOUT THE CASE THE DANGER OF ELECTRIC SHOCK EXISTS. EXERCISE EXTREME CARE.**

The highest voltages are:

| | |
|---|---|
| On Power Supply Chassis | 850 Volts AC |
| On Amplifier Chasis | 300 Volts DC |

### 4.5 The 200 Hour Check

This serves to check the adjustment of PEAK ADJ and SCALE ADJ controls and is performed according to the 2.11.1 and 2.11.3 of Page

### 4.6 The 1000 Hour Check

This entails a check of the general performance of the instrument and consists of the following tests:

Correct the SCALE ADJ and PEAK ADJ as described under 2.11.1 and 2.11.3.

**4.6.1** Check the dc coupled stages V3 and V7 as follows:

a. Remove the case (See 4.4).

b. Short the voltmeter input terminal, set the range switch to 1000 volts, connect the power cord, turn the instrument ON.

c. After 10 minutes warmup measure the dc voltage on Pin 7 of V3 and V7. The voltage should be—

50 to 68 volts for V3 and
100 to 115 volts for V7.

When the voltage is out of limits the tubes V2 or V6 should be replaced. Any tube within the manufacturer's specifications is suitable for replacement. However, for highest stability, tubes with approximately 50 hours of aging under similar conditions as in the voltmeter are recommended.

After tube replacement the Pin 7 voltage should be adjusted to following limits:

| | |
|---|---|
| Pin 7 Tube V3 | 60 volts to 68 volts |
| Pin 7 Tube V7 | 106 volts to 116 volts |

The adjustment is made by connecting an Allen-Bradley Type EB ½ watt resistor in series or in parallel with R18 or R41. An increase in R18 or R41 will increase the voltage. A decrease of R18 or R41 will decrease the Pin 7 voltage.

**4.6.2** Checking the Phase Inverter for Symmetry — Proceed as follows:

a. Connect a distortion-free sine wave source (4.3.1 or 4.3.3) to the input of the voltmeter.

b. Set Function Switch to PEAK-TO-PEAK
Range Switch to any range 350 MV to 3.5 Volts
Polarity Switch to POSITIVE

Adjust the input voltage to produce an accurately readable indication at any point in the upper 1/3 of the meter scale. Note the indication.

c. Switch the Polarity Switch to NEGATIVE. Note the new indication.
The two indications should not differ more than 0.5%. If the difference is more than 0.5% correct as follows:

d. Remove the instrument case (See 4.4).

e. Shunt, or add in series an Allen-Bradley Type EB ½ watt resistor to R21. Add the series resistor when the POSITIVE response is higher than the NEGATIVE response. 100 ohms gives approximately 1% correction.

Shunt R21 when the NEGATIVE response is higher. 1 megohm gives approximately 1% correction.

R21 is located between the Pin 5 of Tube V3 and the lowest terminal board on the amplifier chassis.

**4.6.3** A check of the CAL ADJ control should be A check of the CAL ADJ control should be made only when an accurately calibrated voltage source (4.3.3) of good waveform is available.

A 0.5% or more accurate RMS or average responding laboratory standard instrument could be used with a 400 cycle to 2 kc distortion-free voltage source. Line frequency is not suitable for calibration purposes because of high distortion and too low frequency. When an RMS calibrated instrument is used as a standard the conversion from RMS to peak-to-peak can be made as follows:

1 volt Peak-to-Peak = 0.354 volts RMS of sinewave

For CAL ADJ check proceed:

a. Allow a minimum of 0.5 hours warmup.

b. Check SCALE ADJ as described under 2.11.1.

c. Apply accurate 1 volt Peak-to-Peak ±0.25% to the voltmeter.

Set — Range Switch to 1000 MV
Function Switch to PEAK-TO-PEAK
Polarity Switch to POSITIVE

Adjust CAL ADJ to give an exact reading of 10 on the upper voltage scale. Tap the meter slightly before taking the reading.

### 4.7 The 2000 Hour Check

Includes all checks described under 4.6 PLUS the tube check and the power supply check.

**4.7.1** Tubes should be tested for proper transconductance and low grid current. Any common tube tester may be used for the transconductance test. Tubes with transconductance below the manufacturer's limits should be replaced.

The grid current of Tubes V1, V2 and V6 should be measured by measuring the grid voltage at Pin 1 of those tubes with range switch set to 3.5 millivolts and the input to the voltmeter shorted. The maximum grid voltage is:

Tube 1 +0.05 V
Tube 2 +0.2 V
Tube 6 +0.2 V

Tubes which measure a higher grid voltage should be replaced.

Tubes which measure normal do not have to be replaced until transconductance drops, or grid current or some other fault is observed. Tests at Ballantine Laboratories indicate that this may take over 10,000 hours of operation.

**4.7.2** +B voltage should be measured at Pin 1 of Tube 9. This voltage should be 300 V to 310 V. If the voltage is out of these limits it should be brought within them by adding to, or shunting R56 with Allen-Bradley Type EB resistor.

If Tube V10 in the power supply is replaced, the power supply ripple at Pin 1 of Tube 9 should be checked as described under 5.9.2, page 13. If the ripple is more than 12 mv pp adjustment of R49 should be made to bring the ripple into 12 mv pp limits.

## 5. SERVICE AND TROUBLE SHOOTING

### 5.1 General

In case of voltmeter malfunction, limited servicing by the user is feasible provided skilled personnel and recommended equipment are available and the procedures outlined below are followed.

However, it should be pointed out that the described procedures are only simplified outlines of recommended service and calibration. Refined service and comprehensive calibration requires accurate and special equipment normally not available to the user. Therefore if trouble develops which cannot be corrected by the simplified methods outlined here or when accurate recalibration of the instrument is needed, it is recommended that the voltmeter be returned to Ballantine Laboratories for service and/or recalibration. A letter describing the trouble or desired service will help our Service Department greatly and insure a fast return.

### 5.2 Necessary Equipment

For successful servicing and trouble shooting, the following equipment is needed:

**5.2.1** A DC Voltmeter, 1 Volt to 500 Volts Full Scale ±3%, 10 megohm input resistance (For Test 5.4).

**5.2.2** A sensitive AC voltmeter, 10 cycles to 100 kc, 1 millivolt to 100 volts, ±3% (For Test 5.5). Ballantine Model 300, 300D, 310A, or 302C would be suitable for this purpose.

**5.2.3** Signal Generator 10 cycles to 1 mc, 1 volt output (For Tests 5.5, 5.6, 5.7).

**5.2.4** Approximately calibrated sensitive oscilloscope DC to 1 mc (For Tests 5.6, 5.10).

**5.2.5** Accurate voltage calibrator, 1 volt ± 0.25%, 1 kc, such as Ballantine Model 420 (For Test 5.5).

**5.2.6** Accurate HF voltage source, such as Ballantine Micropotentiometers or Type C. Voltmeter (For Tests 5.6, 5.7).

### 5.3 Simple Service Problems

**5.3.1 Pilot Light Replacement** is accomplished from the front. After unscrewing the red plastic cap the bayonet base pilot light can be removed and replaced with Type 47 bulb.

**5.3.2 Fuse Replacement** — The fuse is Slow-blow type (Bussman MDL or equivalent) rated 1 amp for 115 and 0.5 amp for 230 V operation and may be replaced by unscrewing the fuseholder cap on the front panel.

Before replacement, the reason for fuse failure should be investigated and corrected. Normally it will be on the primary side of the power transformer. Because of the special nature of the regulator transformer a short in the filament or +B circuit does not necessarly burn out the fuse nor harm the power transformer.

**5.3.3 Tube Replacement** — This may be done after removing the case (see 4.4). Any tube within tube manufacturer's specifications can be used for replacement. When replacing tubes V2 and V5 preaging of the tubes for approximately 50 hours is recommended. After replacing those tubes the DC voltages should be checked and adjusted according to the instructions in 4.6.1.

**5.3.4 Conversion to 230 V Operation** — After removing the instrument from the case (see 4.4), consult the wiring diagram at the end of the instruction book for detailed information.

### 5.4 DC Voltage Checks

A check of the DC voltages on tube pins should be undertaken when the voltmeter shows malfunctioning which cannot be corrected by tube replacement.

For DC voltage measurement proceed as follows:

Remove the case (4.4)
Short the input terminals
Set — Range Switch to 1000 V
Function Switch to PEAK-TO-PEAK
Polarity Switch to POSITIVE

Measure tube pin voltages with a 10 megohm input resistance voltmeter and compare the results with the following table:

**TUBE PIN VOLTAGES MEASURED TO THE CHASSIS**

| Tube \ Pin | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| V1 | 0-0.05 | 2.1 | 0 | 6.1 | 90 | 110 | 2.1 | | |
| V2 | 0-0.2 | 1.5 | 12.2 | 18.3 | 55-65 | 100-130 | 1.5 | | |
| V3 | 55-65 | 235-255 | 100 | 100 | 235-255 | 235-255 | 56-68 | | |
| V4 | | 250 | 100 | 100 | 250 | 250 | 110 | | |
| V5 | 0-0.05 | 1.5 | 6.1 | 12.2 | 90-140 | 100-130 | 1.5 | | |
| V6 | 0-0.2 | 1.6 | 100 | 100 | 100-113 | 130-160 | 1.6 | | |
| V7 | 100-113 | 300-310 | 100 | 100 | 300-310 | 300-310 | 102-115 | | |
| V9 | 300-310 | 295 | 150 | 150 | 150 | | 295 | | 385 |
| V10 | 105 | 107 | 150 | 150 | 295 | 150 | 107 | | |
| V11 | 107 | 0 | — | 0 | 107 | — | 0 | | |
| V12 | 70 | 70 | 100 | 100 | 70 | — | — | | |
| V13 | 300-310 | 70 | 93 | 100 | 100 | 300-310 | | 93 | 100 |
| V14 | 93 | 93 | 100 | 100 | 93 | | 90* | | |
| V15 | 300 | 90 | 100 | 100 | 100 | 300 | 90* | 100 | 100 |

*Measured with METER RESET depressed.

All voltages, unless otherwise specified, should be within ±10% of the TABLE VALUES.

If any voltage is outside the specified limit the associated tube should be checked, connections inspected and components measured until the reason for voltage deviation is found and corrected.

### 5.5 Signal Tracing

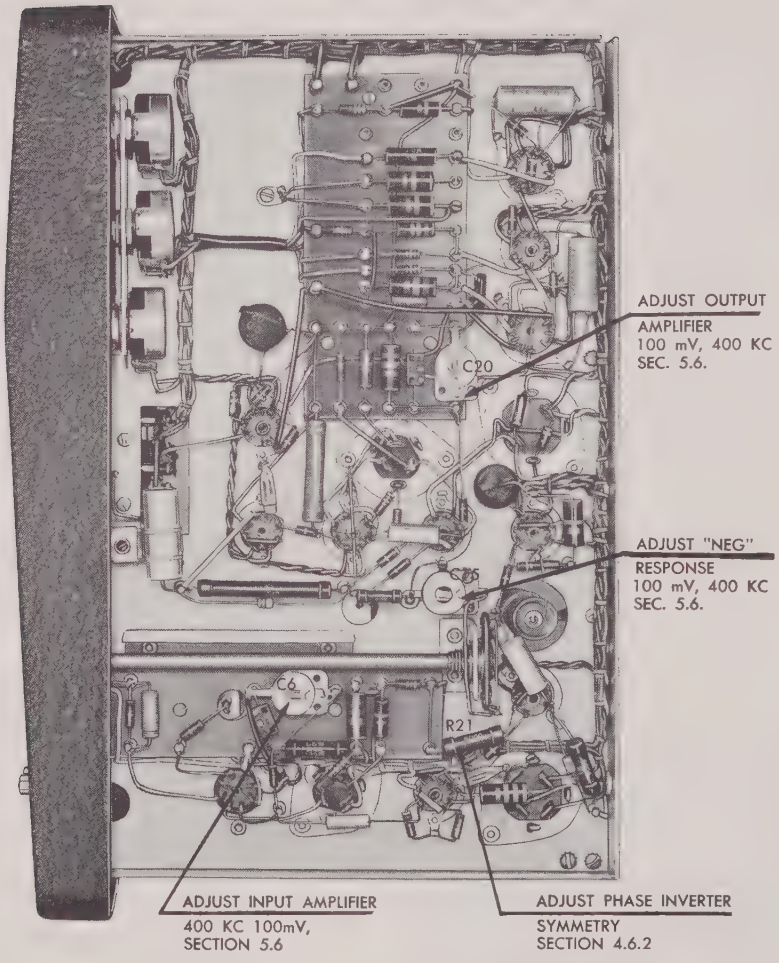
If the reason for the voltmeter malfunction cannot be found by a dc voltage check, signal tracing should be used to locate the trouble.

For signal tracing apply a 1 volt Peak-to-Peak (0.35 volt RMS) 1 kc signal to the input of the voltmeter and set:

Range Switch to 1 VOLT PEAK-TO-PEAK
Function Switch to PEAK-TO-PEAK
Polarity Switch to POSITIVE

Use a sensitive high input impedance voltmeter (5.2.2) to measure the AC voltage at tube pins listed in the table below. The measured voltages should be within ±10% of the listed values.

| *Tube* | *Pin No.* | *Tube Element* | *Voltage V RMS* |
|---|---|---|---|
| V1 | 1 | Control Grid | 0.011 |
| V1 | 2 | Cathode | 0.0107 |
| V2 | 1 | Control Grid | 0.0075 |
| V3 | 1 | Control Grid | 1.45 |
| V3 | 7 | Cathode | 1.36 |
| V3 | 2, 5, 6 | Plate | 1.36 |
| V4 | 1 | Control Grid | 1.36 |
| V4 | 7 | Cathode | 1.30 |
| V5 | 1 | Control Grid | 0.13 |
| V5 | 2.7 | Cathode | 0.126 |
| V6 | 1 | Control Grid | 0.13 to 0.16 |
| V6 | 5 | Plate | 23.5 |
| V7 | 1 | Control Grid | 23.5 |
| V7 | 7 | Cathode | 22.5 |
| V12 | 1 | Cathode | 22.5 |
| V12 | 2 | Plate | 22.5 |


ADJUST OUTPUT
AMPLIFIER
100 mV, 400 KC
SEC. 5.6.
C20
ADJUST "NEG"
RESPONSE
100 mV, 400 KC
SEC. 5.6.
C25
C6
R21
ADJUST INPUT AMPLIFIER
400 KC 100mV,
SECTION 5.6
ADJUST PHASE INVERTER
SYMMETRY
SECTION 4.6.2

If disagreement with the tabulated voltages is found, the whole amplifier in which the discrepancy is found should be checked since in feedback amplifiers trouble in any of the stages will likely affect voltages elsewhere in the circuit.

If all signal voltages measure normal and the incorrect indication is still observed, the peak detector circuit should be checked as follows:

With 1 volt Peak-to-Peak and the voltmeter controls set as above the dc cathode voltages of tubes V13 and V15 should be measured. This measurement should be repeated with the same input signal but with the range switch on 3.5 volts FULL SCALE.

The voltages should be:

| TUBE | PIN | 1 V FS | 3.5 V FS |
|---|---|---|---|
| V13 | 3 | 120 | 104 |
| V13 | 8 | 94 | 97 |
| V15 | 3 | 130 | 112 |
| V15 | 8 | 80 | 97 |

### 5.6 Amplifier Frequency Response Adjustment

This should be corrected when the voltmeter gives a correct indication on the 3.5 millivolt Full Scale Range at mid-frequencies (400 cycles to 2 kc) but an excessive error at higher frequencies.

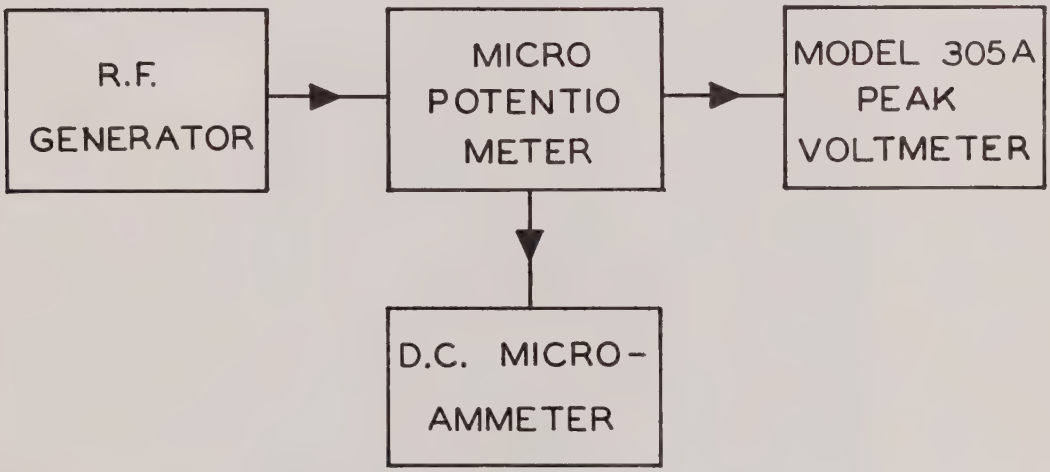
The adjustment of the amplifier response should be made after replacement of defective tubes and components and after the midband accuracy according to 4.6.3 has been checked or corrected. Also, Capacitors C18 and C19 should be checked.

To correct the amplifier frequency response proceed as follows:

a. Remove the instrument from the case (4.4).

b. Set Range Switch to 100 MV
Function Switch to PEAK-TO-PEAK
Polarity Switch to POSITIVE

c. Connect a 15 to 30 millivolt rms micropotentiometer to the voltmeter input and a generator with less than 0.5% distortion to the micropotentiometer, as shown in following diagram.




d. Adjust the signal level to some convenient point on the scale and take the reading.

e. Keeping the micropotentiometer output constant, increase the frequency to 400 kc. The voltmeter should indicate 0.5 to 1% below the previous reading. If not, adjust C6 and C20 to specified limits. Adjustment of C6 and C20 should be made so that both trimmers will have approximately the same capacitance value. The location of C6 and C20 is shown on photograph (Fig. 2).

f. Turn the Polarity Switch to NEGATIVE. Adjust C15 until meter gives the same indication as in POSITIVE position.

### 5.7 Attenuator Frequency Response

Adjustment should be made when the voltmeter exhibits excessive error at higher frequencies on ranges 350 mv to 3.5 volts or 10 volts to 1000 volts. The adjustment of attenuator frequency response should be undertaken only after the amplifier frequency response has been checked or corrected. The adjustment of the 10 volts to 1000 volts range should be done before the adjustment of 350 millivolts to 3.5 volts range because the first adjustment affects the second.

To adjust the attenuator response proceed as follows:

a. Remove the Range and Polarity Switch Knobs and Escutcheon Plate by removing four #4 binder head screws from the front panel.

b. Replace the range switch knob and turn the switch four positions back from the most clockwise position (10 volt range).

Set Function Switch to PEAK-TO-PEAK
Polarity Switch to POSITIVE or NEGATIVE

PEAK VOLTS
DECIBELS
BALLANTINE LABORATORIES, INC
R67
R76
R70
ADJ. ATTN.
200 KC
SEC. 5.7.
350 mV-3.5 V
RANGE
C3
10 V-1000 V
RANGE
C2
BALLANTINE LABORATORIES, INC
PEAK VOLTMETER MODEL 385A

c. Apply 1 kc 3 to 10 volts Peak-to-Peak distortion-free sinewave to the input. Set the input level to a conveniently readable point on the scale.

d. By means of a Ballantine Type C Voltmeter or equivalent accurate device keep the input voltage constant within 0.25%; change the frequency to 200 kc.

e. Adjust trimmer C2 with an insulated screwdriver until the indication is exactly the same as for 1 kc. For location of C2 see photograph (Fig. 3).

To adjust the 350 millivolts to 3.5 volts ranges proceed as follows:

a. Set the range switch to the sixth position clockwise (1 volt).

b. Apply a 1 kc approximately 1 volt Peak-to-Peak distortion-free sinewave to the input and set the level to a convenient point on the scale.

c. Keep the input voltage constant to 0.25% and change the frequency to 200 kc.

d. Adjust Trimmer C3 with screwdriver until the indication is exactly the same as for 1 kc. For location of C3, see photograph (Fig. 3).

e. Replace the escutcheon plate and knobs.

### 5.8 Replacement of Attenuator Resistors

The attenuator resistors are stable and carefully matched in value, temperature coefficient and HF characteristics. They do not dissipate any power and it is very unlikely that trouble with attenuator resistors will occur. Therefore, before changing any resistors, a careful check should be made for any other source of trouble such as loading the attenuator by a tube which draws grid current, etc. After all possible causes are investigated and the instrument still is in error on some ranges at low frequencies (approximately 1 kc), the attenuators should be investigated. Every portion of input and midsection attenuator is used in several ranges as marked on the wiring diagram. The group of ranges which show the error will be the group with the faulty attenuator and the specific resistor can easily be detected.

To correct an attenuator resistor, the value of the suspected resistor, together with other resistors in the same attenuator, should be measured accurately to 0.1%. The measured value should be within 1% of the value stated in the parts list at the end of the instruction book. However, the attenuation ratios figures from the measured resistance values should be within 0.25% of the values stated on Table on Page ?.

If the attenuation value differs by more than 0.25%, the faulty resistor should be replaced with a selected resistor of correct value and of the same type and make, since the selection of one with 0.25% accuracy is highly impractical for most users. It is strongly recommended that the voltmeter be sent to Ballantine Laboratories for service when such trouble occurs.

### 5.9 Servicing the Power Supply

The power supply should be checked if the filament or +B voltages are not normal, or excessive error is observed when measuring 60 cycles or 120 cycles signal or when indication is unstable with stable signal input.

**5.9.1 Shorts in filament or +B circuit** do not normally cause the fuse to blow because of the characteristics of the power transformer. This also does not damage the transformer.

Small deviations in +B voltage from +300 to +310 volts measured on Pin 1 of Tube 9 should be corrected as described under 4.7.2.

If the +B measures approximately 250 volts and heater voltages 4.5 volts rms, a short circuit in Tubes 9 and 10 filament may be suspected.

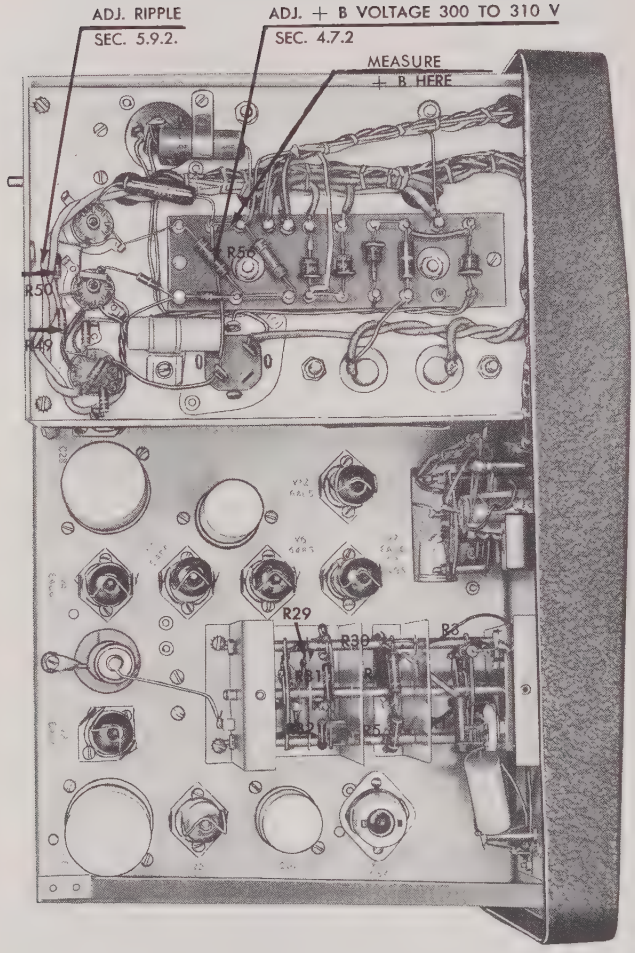
If the +B measures approximately 150 volts and all tubes look unlit, a short circuit in the amplifier filament circuits may be suspected.

A short circuit in +B circuit or defective by-pass or filter capacitor causes the burnout of R44 and results in no +B voltage.

**5.9.2 Excessive Hum** in +B Voltage or Tubes V1, V2 or V5 filament circuit causes a high error when making 60 cycle or 120 cycle measurements, and increases 60 cycle or 120 cycle component at the amplifier output with shorted input. In a normal instrument the amplitude of random noise equals that of 60 cycle or 120 cycle component.

The peak-to-peak hum amplitude on Pin 1 of Tube 9 could be measured by using another peak responding voltmeter or calibrated oscilloscope. If the hum is higher than specified, Tube V10 should be changed or R49 or R50 shunted by an Allen-Bradley Type EB resistor. The value of the shunt resistor can be found experimentally and would be greater than 1 megohm.

**5.9.3 Instability of Indication** in form of random pointer fluctuation above 100 millivolt ranges may be caused by a faulty reference Tube V11 which should be replaced. If the instability occurs on sensitive ranges of the instrument, shielding of the input wiring should be checked for RF pickup.


ADJ. RIPPLE
SEC. 5.9.2.
ADJ. + B VOLTAGE 300 TO 310 V
SEC. 4.7.2
MEASURE
+ B HERE
R56
R50
R49
R29
R30

### 5.10 Trouble Shooting

| Symptoms | Possible Cause | Pertinent Section |
|---|---|---|
| Instrument inoperative<br>Pilot light does not light | No power<br>Blown fuse<br>Defect in power supply | 5.3.2 |
| Meter indicating with no input | Input not shielded, picks up hum<br>PEAK ADJ off<br>Defective tube (heater cathode leak) | 2.11.3 |
| Microphonics | Microphonic tube V1 or V5<br>Loose connection | |
| High error at 60 and 120 cycle measurement | Hum pickup in the connections<br>Ground current in measuring circuit<br>Strong magnetic field<br>Heater damage in V1, V2, V5<br>High hum of power supply | 5.9.2 |
| Unstable indication | Insufficient shielding in input wiring<br>Defective V11<br>Defective power supply | 5.9 |
| Inaccurate peak measurement | Misadjusted PEAK ADJ<br>Defective V6 | 2.11.3 |
| Impossible to set SCALE ADJ | Tubes V12, V13, V14, V15<br>Resistors R70, R73, R74 | |
| High error in lower part of the scale | SCALE ADJ needs adjustment | 2.11.1 |
| Error in NEGATIVE position only | Defective Resistor R21 | 4.6.2 |
| High frequency response or short pulse measurement in error in POS and NEG position | Frequency response of the amplifiers or attenuators incorrect | 5.6<br>5.7 |
| Same in NEGATIVE position only | C15 misadjusted | 5.6 |
| DC Voltages abnormal | Defective power supply V9, V11<br>Short in tubes or circuit | 5.9 |

## REPLACEMENT PARTS LIST

REFER TO MODEL 305A SCHEMATIC DIAGRAM, ISSUE C

| *B. L. Part No.* | *Circuit Symbol* | *Condensers* | *Manufacturer* |
|---|---|---|---|
| 2263 | C1 | .1 μF, 600 V, 5%, Type 663-UW | Goodall |
| 2438 | C2 | 1-5 pF, Type 5M11-160-102 | E. F. Johnson |
| 2429 | C3 | 7-45 pF, Type 503-27 | Erie |
| 2251 | C4 | 62 pF, 500 V, 5%, Type CM-15 | Arco |
| 2253 | C5 | 3,300 pF, 500 V, 5%, Type CM-30 | Arco |
| 2429 | C6 | 7-45 pF, Type 503-27 | Erie |
| 2236 | C7 | 200 pF, 500 V, 5%, Type CM-15 | Arco |
| 2752 | C8A | 10 μF, 350 V, Type FP | Mallory |
| 2752 | C8B | 50 μF, 350 V, Type FP | Mallory |
| 2752 | C8C | 60 μF, 350 V, Type FP | Mallory |
| 2372 | C9 | .022 μF, 200 V, 10%, Type 663-UW | Goodall |
| 2753 | C10A | 20 μF, 300 V, Type DFP | Sprague |
| 2753 | C10B | 20 μF, 300 V, Type DFP | Sprague |
| 2753 | C10C | 30 μF, 50 V, Type DFP | Sprague |
| 2080 | C11 | 35 μF, 6 V, Type 30D132 | Sprague |
| 2510 | C12 | .47 μF, 10%, Type QC | Quality |
| 2367 | C13 | .1 μF, 200 V, 10%, Type 6630-UW | Goodall |
| 2364 | C14 | .033 μF, 200 V, 5%, Type 663-UW | Goodall |
| 2431 | C15 | 3-12 pF, Type 503-27 | Erie |
| 2535 | C16 | .01 μF, (—0+100) 6 mc tol., Type BYA6S1 | Cornell-Dubilier |
| 2067 | C17 | 12 μF, 250 V, Type BR-1225 | Cornell-Dubilier |
| 2508 | C18 | 6.2 pF, 5%, Type QC | Quality |
| 2248 | C19 | 18 pF, 500 V, 5%, Type CM-15 | Arco |
| 2429 | C20 | 7-45 pF, Type 503-27 | Erie |
| 2236 | C21 | 200 pF, 500 V, 5%, Type CM-15 | Arco |
| 2371 | C22 | .047 μF, 200 V, 10%, Type 663-UW | Goodall |
| 2753 | C23A | 20 μF, 300 V, Type DFP | Sprague |
| 2753 | C23B | 20 μF, 3000 V, Type DFP | Sprague |
| 2753 | C23C | 30 μF, 50 V, Type DFP | Sprague |
| 2509 | C24 | 1 pF, 10%, Type QC | Quality |
| 2370 | C26 | .22 μF, 400 V, 10%, Type 663-UW | Goodall |
| 3052 | C27 | .85 pF, 850 V | Sola |
| 2754 | C28A | 1,000 μF, 25 V, Type WP | Mallory |
| 2754 | C28B | 1,000 μF, 25 V, Type WP | Mallory |
| 2751 | C29 | 80 μF, 300 V, Type FP | Mallory |
| 2750 | C30A | 80 μF, 350 V, Type FP | Mallory |
| 2750 | C30B | 20 μF, 350 V, Type FP | Mallory |
| 2370 | C31 | .22 μF, 400 V, 10%, Type 663-UW | Goodall |
| 2228 | C32 | 50 pF, 500 V, 5%, Type CM-15 | Arco |
| 2256 | C33 | 500 pF, 500 V, 10%, Type DM-15 | Arco |
| 2354 | C34 | .15 μF, 200 V, Type 663-UW | Goodall |
| 2354 | C35 | .15 μF, 200 V, Type 663-UW | Goodall |

## REPLACEMENT PARTS LIST *Continued*

REFER TO MODEL 305A SCHEMATIC DIAGRAM, ISSUE C

| *B. L. Part No.* | *Circuit Symbol* | *Resistors* | *Manufacturer* |
|---|---|---|---|
| 1460 | R1 | 2,000,000 ohms, Type CP-1, 1% | Aerovox |
| 1063 | R2 | 300 ohms, Type EB, 5% | Allen-Bradley |
| 2663 | R3 | 67,500 ohms, Type CP-½, 1% | Aerovox |
| 2665 | R4 | 63.3 ohms, Type CP-½, 1% | Aerovox |
| 2664 | R5 | 1,940 ohms, Type CP-½, 1% | Aerovox |
| 1099 | R6 | 10 ohms, Type EB, 10% | Allen-Bradley |
| 1460 | R7 | 2,000,000 ohms, Type CP-1, 1% | Aerovox |
| 1057 | R8 | 1,000 ohms, Type EB, 5% | Allen-Bradley |
| 1662 | R9 | 30,000 ohms, Type N25, 2% | Corning |
| 1086 | R10 | 1,500 ohms, Type EB, 5% | Allen-Bradley |
| 1065 | R11 | 200 ohms, Type EB, 5% | Allen-Bradley |
| 1440 | R12 | 69.8 ohms, Type CP-½, 1% | Aerovox |
| 1091 | R13 | 91,000 ohms, Type EB, 5% | Allen-Bradley |
| 1015 | R14 | 470,000 ohms, Type EB, 5% | Allen-Bradley |
| 1064 | R15 | 220 ohms, Type EB, 5% | Allen-Bradley |
| 1213 | R16 | 33,000 ohms, Type HB, 5% | Allen-Bradley |
| 1206 | R17 | 5,100 ohms, Type HB, 5% | Allen-Bradley |
| 1251 | R18 | 100,000 ohms, Type GB, 5% | Allen-Bradley |
| 1071 | R19 | 47 ohms, Type EB, 10% | Allen-Bradley |
| 1082 | R20 | 240 ohms, Type EB, 5% | Allen-Bradley |
| 1479 | R21 | 9,000 ohms, Type CP-1, 1% | Aerovox |
| 1479 | R22 | 9,000 ohms, Type CP-1, 1% | Aerovox |
| 1071 | R23 | 47 ohms, Type EB, 10% | Allen-Bradley |
| 1012 | R24 | 750,000 ohms, Type EB, 5% | Allen-Bradley |
| 1258 | R25 | 10,000 ohms, Type GB, 5% | Allen-Bradley |
| 1063 | R26 | 300 ohms, Type EB, 5% | Allen-Bradley |
| 1201 | R27 | 20,000 ohms, Type HB, 5% | Allen-Bradley |
| 1057 | R28 | 1,000 ohms, Type EB, 5% | Allen-Bradley |
| 1654 | R29 | 15,000 ohms, Type N20, 1% | Corning |
| 1658 | R30 | 4,740 ohms, Type N20, 1% | Corning |
| 1657 | R31 | 1,500 ohms, Type N20, 1% | Corning |
| 1655 | R32 | 694 ohms, Type N20, 1% | Corning |
| 1214 | R33 | 27,000 ohms, Type HP, 5% | Allen-Bradley |
| 1057 | R34 | 1,000 ohms, Type EB, 5% | Allen-Bradley |
| 1071 | R35 | 47 ohms, Type EB, 10% | Allen-Bradley |
| 1440 | R36 | 69.8 ohms, Type CP-½, 1% | Aerovox |
| 1085 | R37 | 120,000 ohms, Type EB, 5% | Allen-Bradley |
| 1015 | R38 | 470,000 ohms, Type EB, 5% | Allen-Bradley |
| 1663 | R39 | 18,000 ohms, Type LP1-4 | Corning |
| 1098 | R40 | 120 ohms, Type EB, 5% | Allen-Bradley |
| 1252 | R41 | 62,000 ohms, Type GB, 5% | Allen-Bradley |
| 1071 | R42 | 47 ohms, Type EB, 10% | Allen-Bradley |
| 1506 | R43 | 12,500 ohms, Type CP-2, 1% | Aerovox |
| 1271 | R44 | 10 ohms, Type GB, 10% | Allen-Bradley |
| 1015 | R45 | 470,000 ohms, Type EB, 5% | Allen-Bradley |
| 1015 | R46 | 470,000 ohms, Type EB, 5% | Allen-Bradley |
| 1739 | R47 | 22 ohms, Type 151E, 5% | Sprague |

## REPLACEMENT PARTS LIST *Continued*

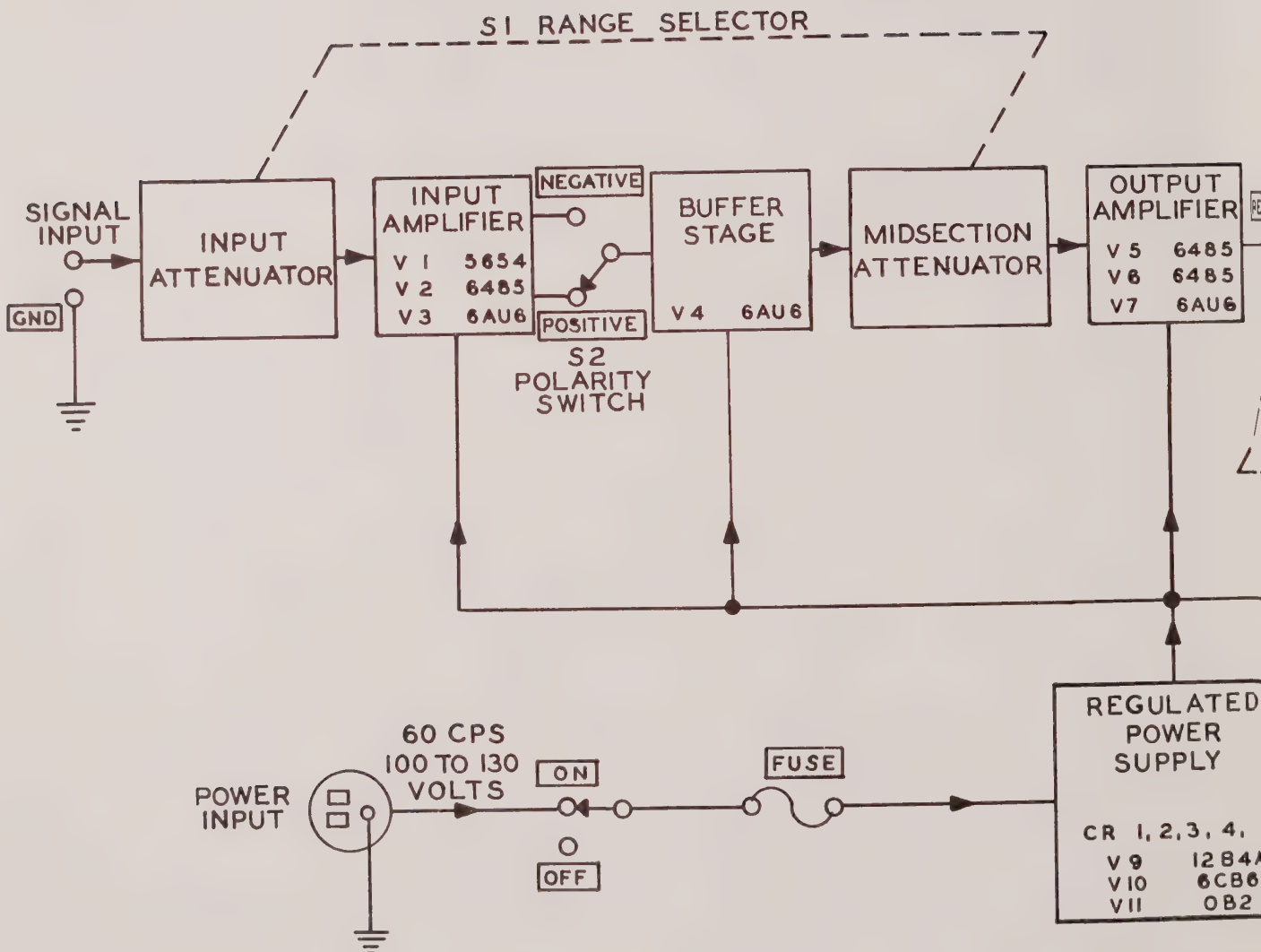
REFER TO MODEL 305A SCHEMATIC DIAGRAM, ISSUE C

| *B. L. Part No.* | *Circuit Symbol* | *Resistors* | *Manufacturer* |
|---|---|---|---|
| 1015 | R48 | 470,000 ohms, Type EB, 5% | Allen-Bradley |
| 1021 | R49 | 270,000 ohms, Type EB, 10% | Allen-Bradley |
| 1032 | R50 | 47,000 ohms, Type EB, 5% | Allen-Bradley |
| 1071 | R51 | 47 ohms, Type EB, 10% | Allen-Bradley |
| 1741 | R52 | 25,000 ohms, Type 27E, 5% | Sprague |
| 1732 | R53 | 1,500 ohms, Type SKT, 5% | Sprague |
| 1303 | R54 | 250,000 ohms, Type CP-½, 1% | Aerovox |
| 1021 | R55 | 270,000 ohms, Type EB, 5% | Allen-Bradley |
| 2666 | R56 | 135,000 ohms, Type CP-½, 1% | Aerovox |
| 1001 | R57 | 10,000,000 ohms, Type EB, 10% | Allen-Bradley |
| 1004 | R58 | 3,900,000 ohms, Type EB, 5% | Allen-Bradley |
| 1000 | R59 | 22,000,000 ohms, Type EB, 5% | Allen-Bradley |
| 1214 | R60 | 27,000 ohms, Type HB, 5% | Allen-Bradley |
| 1254 | R61 | 27,000 ohms, Type GB, 10% | Allen-Bradley |
| 1015 | R62 | 470,000 ohms, Type EB, 5% | Allen-Bradley |
| 1000 | R63 | 22,000,000 ohms, Type EB, 5% | Allen-Bradley |
| 1000 | R64 | 22,000,000 ohms, Type EB, 5% | Allen-Bradley |
| 1015 | R65 | 470,000 ohms, Type EB, 5% | Allen-Bradley |
| 1085 | R66 | 120,000 ohms, Type EB, 5% | Allen-Bradley |
| 1832 | R67 | 50,000 ohms, Type 43-50, 000 | Clarostat |
| 1017 | R68 | 390,000 ohms, Type EB, 5% | Allen-Bradley |
| 1071 | R69 | 47 ohms, Type EB, 10% | Allen-Bradley |
| 1835 | R70 | 2,000 ohms, Type 43-2000 | Clarostat |
| 1071 | R72 | 47 ohms, Type EB, 10% | Allen-Bradley |
| 1209 | R73 | 30,000 ohms, Type HB, 5% | Allen-Bradley |
| 1216 | R74 | 15,000 ohms, Type HB, 5% | Allen-Bradley |
| 1733 | R75 | 70,000 ohms, Type WWA-26 | Dale |
| 1833 | R76 | 25,000 ohms, Type 43-25, 000 | Clarostat |
| 1059 | R77 | 750 ohms, Type EB, 5% | Allen-Bradley |
| 1050 | R78 | 3,900 ohms, Type EB, 5% | Allen-Bradley |

## REPLACEMENT PARTS LIST *Continued*

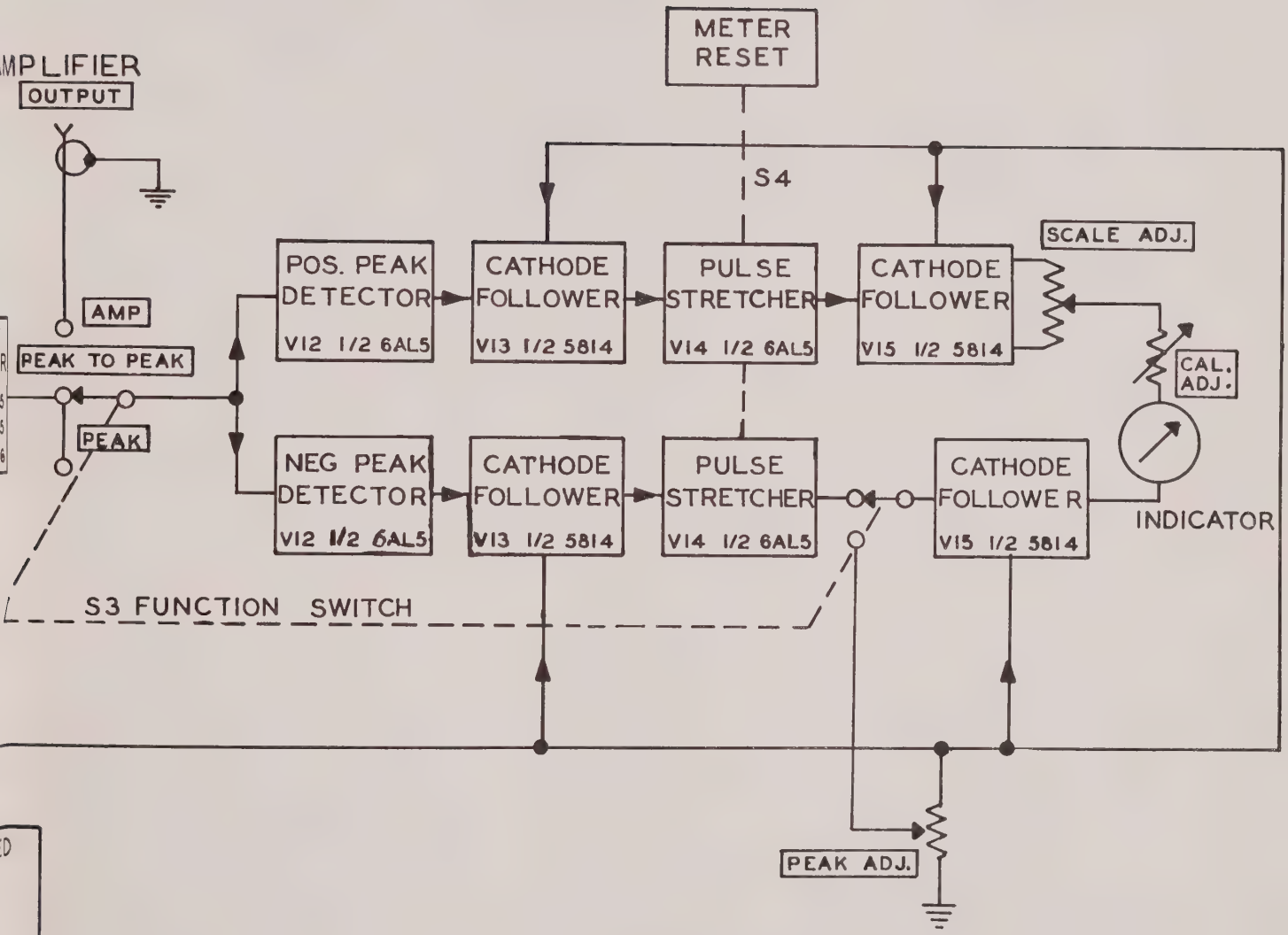
REFER TO MODEL 305A SCHEMATIC DIAGRAM, ISSUE C

| *B. L. Part No.* | *Circuit Symbol* | *Other Components* | *Manufacturer* |
|---|---|---|---|
| 5574 | CR1, 2 | 500 MA, P1V, 400 V, Type 1N1763 | RCA |
| 5579 | CR3, 4 | 500 MA, P1V, 100 V, Type 1N1692 | Transitron |
| 3407 | F1 | Fuse, 1 amp, Type MDL | Bussmann |
| 3451 | I1 | Pilot Light, Type 47 | General Electric |
| 3187 | M1 | Indicating Meter | Ballantine |
| 3265 | S1A, B, C | Attenuator Switch, Type H | Ballantine |
| 3266 | S2 | Positive-Negative Switch, Type 23 | Ballantine |
| 3267 | S3A, B | Peak-to-Peak Switch, Type H | Ballantine |
| 3238 | S4A, B | Push Button Switch, Type 64500-170 | Ballantine |
| 3268 | S5 | ON-OF Switch, Type 80994H | Arrow-Hart, Hegeman |
| 3052 | T1 | Power Transformer | Ballantine |
| 3126 | V1 | Type 5654 Tube | General Electric |
| 5570 | V2 | Type 6485 Tube | Raytheon |
| 3109 | V3 | Type 6AU6 Tube | RCA |
| 3109 | V4 | Type 6AU6 Tube | RCA |
| 5570 | V5 | Type 6485 Tube | Raytheon |
| 5570 | V6 | Type 6485 Tube | Raytheon |
| 3109 | V7 | Type 6AU6 Tube | RCA |
| 3138 | V8 | Type NE-2 | General Electric |
| 5569 | V9 | Type 12B4A Tube | RCA |
| 3149 | V10 | Type 6CB6 Tube | RCA |
| 5578 | V11 | Type OB2WA Tube | CBS |
| 3108 | V12 | Type 6AL5 Tube | RCA |
| 3133 | V13 | Type 5814A Tube | General Electric |
| 3108 | V14 | Type 6AL2 Tube | RCA |
| 3133 | V15 | Type 5814A Tube | General Electric |
| 3138 | V16 | Type NE-2 | General Electric |



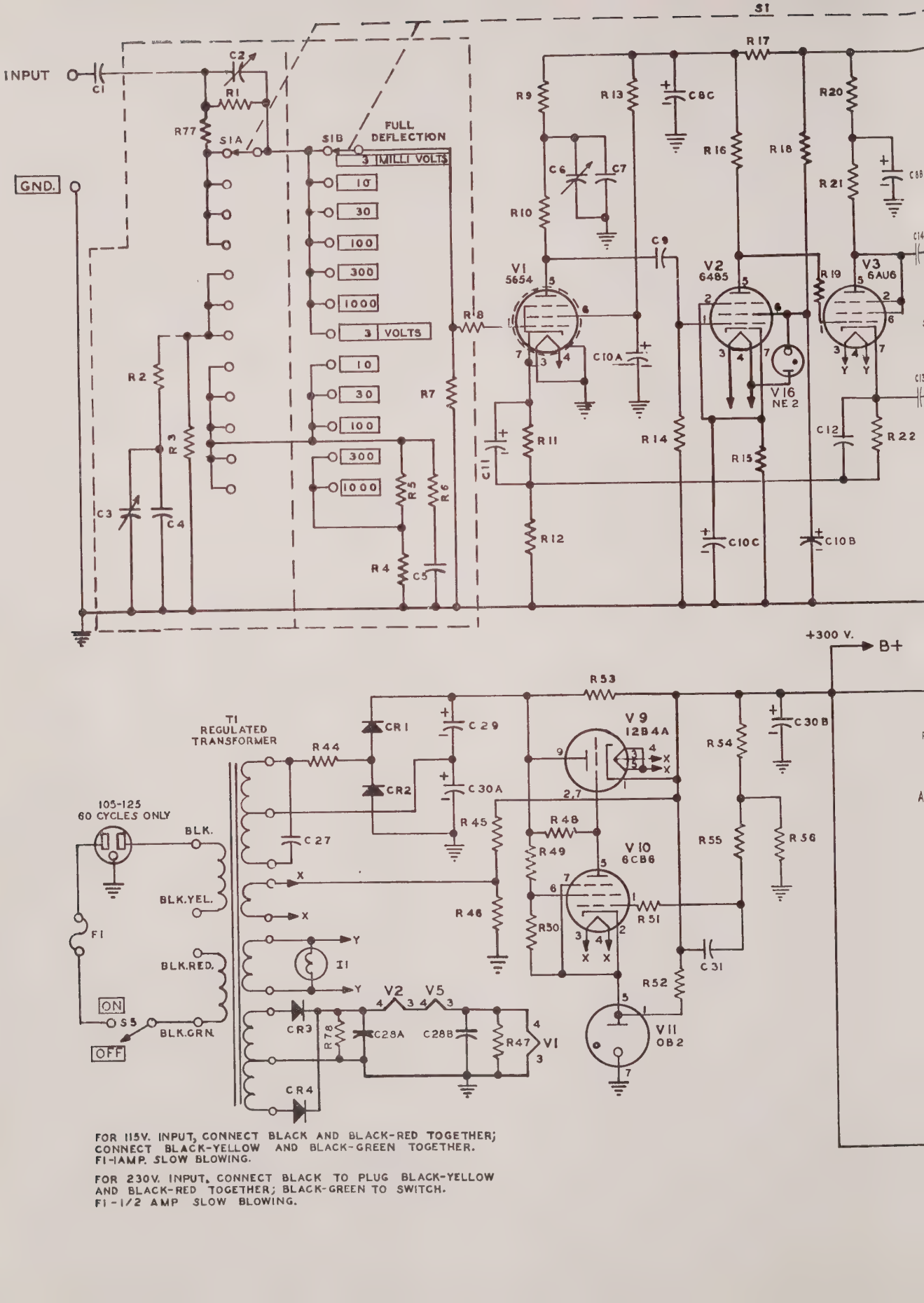

BLO

MODEL 305A PEAK RES



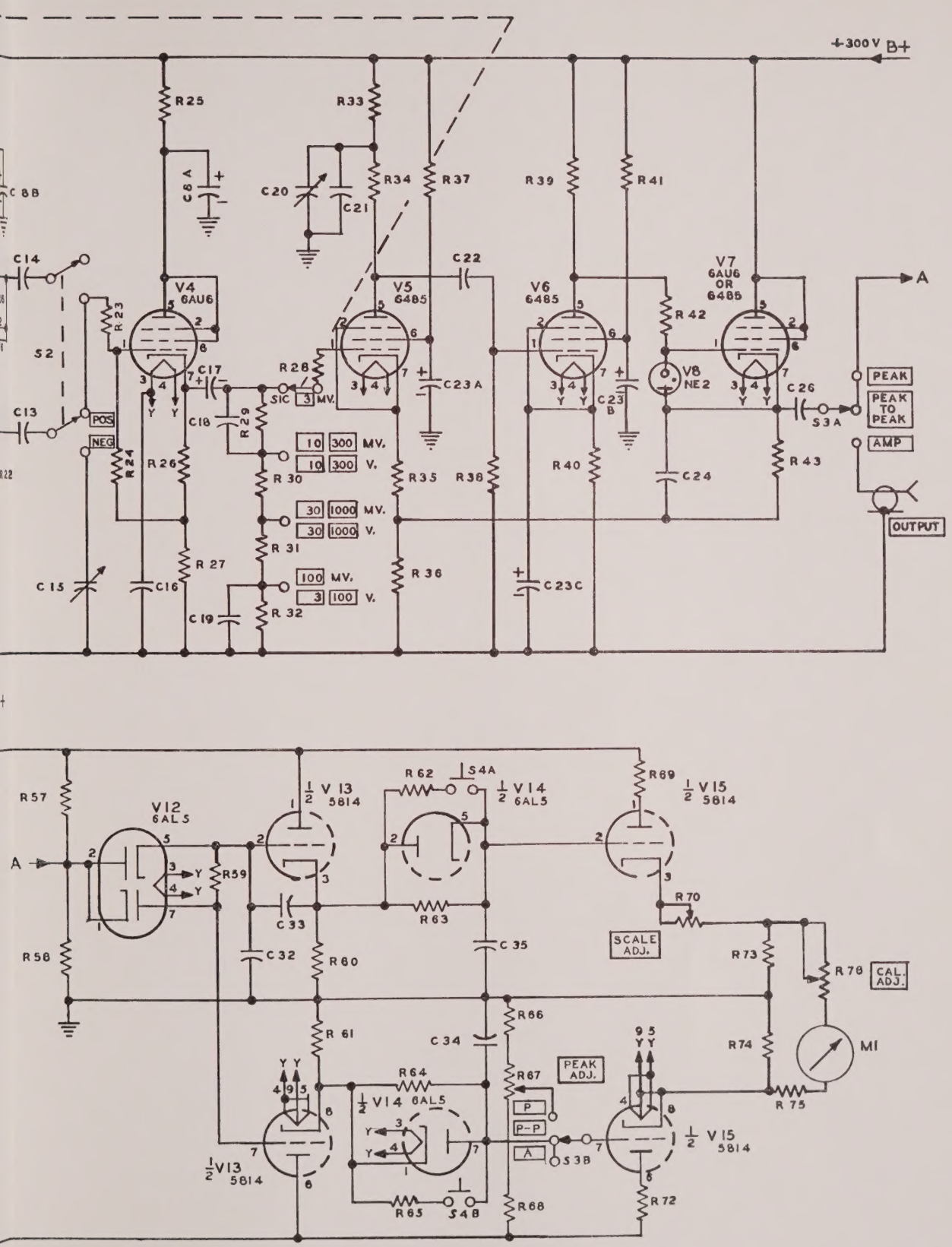

# OCK DIAGRAM

SPONDING ELECTRONIC VOLTMETER




FOR 115V. INPUT, CONNECT BLACK AND BLACK-RED TOGETHER; CONNECT BLACK-YELLOW AND BLACK-GREEN TOGETHER. F1-1AMP. SLOW BLOWING.

FOR 230V. INPUT, CONNECT BLACK TO PLUG BLACK-YELLOW AND BLACK-RED TOGETHER; BLACK-GREEN TO SWITCH. F1-1/2 AMP SLOW BLOWING.







# PEAK RESPONDING VOLTMETER
# MODEL 305 A
## ISSUE MC-1162 C

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